ENVIRONMENTAL SENSITIVITY INDEX: COLUMBIA RIVER

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the estuarine and riverine areas of the Columbia River up to the John Day Dam and the Willamette River up to the locks at Oregon City. The ESI maps are a compilation of information from three main categories: shoreline habitats; sensitive biological resources; and human-use resources.

The individual map pages in this atlas are divided according to the U.S. Geological Survey (USGS) topographic quadrangle index. Black and white scanned images of these maps are used as a backdrop for each map page in the atlas. The name and date on the bottom right of each map page refer to the corresponding USGS quadrangle and its publication or latest photorevision date.

SHORELINE HABITAT MAPPING

The shoreline habitats of the Columbia River from the jetties up to the John Day Dam and the Willamette River from its mouth up to Oregon City were mapped during overflights and ground surveys conducted by an experienced coastal geologist in October 2003. The overflights were conducted at elevations of 400-600 feet and slow air speed. During this work, the ESI shoreline classification was denoted directly onto the shoreline depicted on 1:24,000-scale USGS topographic maps. Where appropriate, revisions to the existing shoreline were made and, where necessary, multiple habitats were described for each shoreline segment.

To determine the sensitivity of a particular intertidal shoreline habitat, the following factors are integrated:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affect the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. The potential for biological injury and ease of cleanup of spilled oil are also important factors in the ESI ranking. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for the Columbia River region, presented in order of increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
1B) Exposed, Solid Man-made Structures
2A) Exposed Wave-cut Platforms in Bedrock
3A) Fine- to Medium-grained Sand Beaches
3B) Scarps and Steep Slopes in Sand
4) Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores
8B) Sheltered, Solid Man-made Structures
8C) Sheltered Riprap
9A) Sheltered Tidal Flats
9B) Sheltered, Vegetated Low Banks
10A) Salt- and Brackish-water Marshes
10B) Freshwater Marshes
10C) Swamps
10D) Scrub-Shrub Wetlands

All of the shoreline habitats are described on pages 7-13 in terms of their physical description, predicted oil behavior, and response considerations.

Wide intertidal habitats, such as rock platforms and tidal flats, were mapped as polygons where appropriate. Only the outer edge of wetland habitats was mapped during the overflights. To provide information on the areal extent of wetlands along the river, wetland polgyons derived from the U.S. Fish and Wildlife Service's National Wetlands Inventory were plotted on the maps. These polygonal wetland types were not checked or edited extensively as a part of this project.

SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected, compiled, and reviewed with the assistance of biologists and resource experts from Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), Oregon State University (OSU), Washington Department of Ecology (WADOE), Washington State Parks (WSP), Oregon State Parks (OSP), Department of the Interior (DOI), Bureau of Land Management (BLM), and the Lower Columbia River Estuary Program (LCREP). Information collected and depicted on these maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Seven major categories of biological resources are included in this atlas: terrestrial mammals, marine mammals, birds, reptiles, fish, invertebrates, and benthic habitats/rare plants.

MARINE MAMMALS
- Pinnipeds

BIRDS
- Diving Birds
- Gulls and Terns
- Passerine Birds
- Raptors
- Shorebirds
- Wading Birds
- Waterfowl

TERRESTRIAL MAMMALS
- Small Mammals
- Ungulates

FISH
- Fish

REPTILES
- Turtles

INVERTEBRATES
- Bivalves
- Crabs

HABITATS
- Floating or Submersed Aquatic Vegetation

TERRESTRIAL MAMMALS

Terrestrial mammals depicted in this atlas include one endangered species as well as several common species. The federally endangered Columbian white-tailed deer (*Odeocoileus virginianus leucurus*) is a prevalent terrestrial mammal in Columbia River estuary. This sub-specie of deer inhabits low-lying mainland areas and islands long the Columbia River from about Skamakowa, Washington, to Port Westward, Oregon. Habitat loss and low productivity have severely reduced the number of deer present and population numbers now range from about 300-500 individuals. The majority of the remaining population inhabits the Julia Butler Hansen National Wildlife Refuge (NWR), which is located in the eastern reaches of the estuary. In addition, areas with highly abundant populations of semi-aquatic fur-bearing mammals, such as the river otter, are also shown on the maps. River otter, mink, beaver, and nutria distributions are based on expert opinion (2004), USFWS maps (1984), and Oil Spill Recovery Plan maps (1979). These distributions are depicted mainly in aquatic habitats such as in or along certain rivers or on islands within the Columbia River mainstem.

The expert contact for the Columbian white-tailed deer is Alan Clark (USFWS) at the Julia Butler Hansen NWR (360-795-3915).

Terrestrial mammals are displayed on the maps as polygons with a brown vertical hatch pattern, or as point occurrences indicated by a small brown dot. In cases where multiple resource types inhabit the same polygon (such as mammals and birds), a black hatch, multi-group pattern is used rather than a brown hatch pattern. A brown icon with a small mammal silhouette is used to indicate the presence of terrestrial mammals and is associated with all polygons or points containing these resources. In the case of the Columbian white-tailed deer, a brown icon with a deer silhouette is used in association with points or polygons containing this species.

The RAR# under the icon (or icon group) on the map references a table on the reverse side of the map. In this table, the first column gives the species name. The second column indicates whether the species is listed as a species of special concern (C), threatened (T), or endangered (E) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentrations for terrestrial mammals were represented with either an estimate of individuals present or, in the absence of specific numbers, by using a descriptive term, such as "present" or "high". "Present" is used for endangered or rare species that were known to occur at a site where more detailed concentration information was not available. Descriptive concentrations are based on the opinion of local resource managers or experts concerning relative concentrations within the study area. In many cases, concentration information is not well known. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an "X" is placed in the month column.

MARINE MAMMALS

Marine mammals depicted in the Columbia River atlas include Steller sea lions (federally threatened), California sea lions, and harbor seals. Seal areas shown on the maps represent major haul-out sites and pupping areas. Of the three pinniped species occurring in the Columbia River, only the harbor seal breeds in the estuary and can be considered a resident. The other two species, California sea lion and Steller sea lion, are migratory and use the estuary seasonally. Haul-out sites for all species have been indicated on the maps as either a point or a polygon. In addition to haul-out areas shown on the maps, harbor seals and California sea lions may be present throughout the estuary and may venture further up river and into some of the tributaries. Harbor seal feeding concentrations are often located in waters adjacent to major haul-out sites, but occur in other areas as well. Information on marine mammal distribution and abundance was provided by ODFW staff and WDFW priority habitat digital data. Though not considered threatened or endangered species, it should be noted that harbor seals and California sea lions are legally protected by the Marine Mammal Protection Act.

Expert contacts for marine mammals in the Columbia River are Robin Brown (ODFW, Corvallis, OR), 541/757-4186; Matthew Tennis (ODFW, Astoria, OR); and Brent Norberg (NOAA, Seattle, WA), 206/526-6733.

The species that were mapped are described below:

Steller sea lion - (Federal threatened, listed 1990)

Steller sea lions are migratory inhabitants of the Columbia River and can be found primarily on the South Jetty in the mouth of the estuary. Most of the Steller sea lions utilizing this haul out are females and young. Relatively few large males are present. Maximum densities of Steller sea lions (80-100) occur in January and through the winter and spring. Few Stellar sea lions are present in the summer and fall.

California sea lion

California sea lions utilize the rocky tip at the South Jetty in the mouth of the Columbia River as their primary haul-out site. They may also be found throughout the estuary and during the winter they are numerous in the upriver portion of the estuary. The use of the river from January through March corresponds to the annual run of smelt, lamprey, and steelhead.

Harbor seal

The harbor seal is the only permanent resident of the Columbia River estuary. Populations fluctuate from about 500 in the summer to 1,500 in the winter with abundances being greatest in the winter and mid-spring. Harbor seals tend to utilize sand bars and rocky islands as haul-out sites and may be present at Desdemona, Taylor, and Miller sands as well as several other locations at low tide.

Marine mammal areas are displayed on the maps as polygons with a brown hatch pattern. In cases where multiple resource types inhabit the same polygon (such as marine mammals and fish), a black hatch, multi-group pattern is used rather than a brown hatch pattern. A brown icon with a seal silhouette is used to indicate the presence of marine mammals and is associated with all polygons containing these resources.

The RAR# under the icon (or icon group) on the map references a table on the reverse side of the map. In this table, the first column gives the species name. The second column indicates whether the species is listed as a species of special concern (C), threatened (T), or endangered (E) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Concentration was represented as the annual peak number of individuals present at a specific haul out site. In the absence of specific numbers, concentration was represented as a descriptive term, such as "high". Descriptive concentrations are based on the opinion of local resource managers or experts concerning relative concentrations within the study area. In many cases, concentration information is not well known. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an "X" is placed in the month column. The final columns list the time periods for sensitive life-history activities, such as mating and pupping.

BIRDS

Birds in this atlas are divided into several species subgroups based on taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. The species table lists all the birds included on the maps, sorted by subgroup. These species are included either because of their likelihood of direct or indirect impact by an oil spill or similar incident, their general rarity or imperilment, or their special protection status as threatened or endangered. Migratory or wintering concentration areas, nesting sites and colonies, and protected species are especially emphasized. Waterfowl, shorebird, and wading bird data were compiled from various reports and information provided by USFWS, ODFW, and adapted from WDFW digital priority habitat data. Also, data on Caspian terns and other seabirds were derived from the Columbia River Bird Research 2003 Season Summary (Roby et al. 2001).

Eagle nests and feeding areas - (Federal/state threatened)

Nesting locations for bald eagles are shown. These data are a compilation of surveys conducted over a 20-year period by OSU. Only nests that have been active within the last five years were included on the maps. Exact nest sites may vary from year to year. Bald eagle nest locations are shown as green points on the maps. These points may or may not indicate the exact position of the nests in order to protect sensitive nesting locations. Where multiple nests were found in the same location, a polygon was used to show the distribution of those nests. Locations are also shown where bald eagles have been documented as being present in high numbers feeding along rivers and in bays. Information on raptor feeding areas was gathered during interviews with ODFW and NOAA staff.

Terns and diving bird nesting and roosting

Locations are shown on the maps where terns and diving birds have been documented as nesting. Of particular note is East Sand Island in the Columbia River estuary, which supports the largest breeding colony of Caspian terns in the world (~9,900 pairs, Collis et al. 2002). This island also provides breeding habitat for the largest known Pacific coast colony of double-crested cormorants (~8,700 pairs) and large numbers of Brandt's cormorants (40-80 pairs). It is the largest nighttime roost for the brown pelican (federally endangered) (>10,000 individuals). Several additional islands and nearshore areas within the estuary also support large numbers of nesting and migrating terns and diving birds. Users should be aware that seabirds may be feeding and rafting in nearshore areas throughout the estuary in the vicinity and up to several miles away from their nests. During a spill, the experts listed below should be contacted for information on current locations.

Waterfowl

Waterfowl are seasonally abundant throughout the Columbia River during the fall and winter months. Locations are shown where waterfowl are nesting and feeding along the river as determined by expert opinion from ODFW, USFWS, and NOAA staff, as well as WDFW priority habitat data. USFWS waterfowl data were derived from aerial surveys conducted annually. Intertidal marshes and agricultural areas in the lower river provide key habitat for an abundance of waterfowl including mallards, northern pintails, wigeons, Canada geese, scaup, and scoters. These species also tend to utilize small embayments and coves along the Columbia River, as well as areas within the mainstem, as feeding and resting areas. Waterfowl species of particular concern include the dusky Canada goose and the Aleutian goose (federally threatened).

Wading bird roosting/nesting

Nesting and roosting locations for wading birds are shown on the maps. Nesting sites for wading birds such as the great blue heron were generally depicted on the maps as large polygons to protect the exact location of sensitive breeding areas. Roosting and foraging sites for the sandhilll crane (Washington state endangered) are also indicated on the maps. Sandhill cranes utilize open wetlands for roosting and are especially prevalent in the Ridgefield NWR Complex and the Sauvie Island Wildlife Management Area (Engler et al., 2004). Data concerning wading bird roosting, foraging, and nesting locations were compiled from expert information gathered from USFWS and ODFW staff and adapted from WDFW priority habitat digital data.

Migratory shorebird stopover

Areas where large concentrations of migratory shorebirds occur annually during the spring and fall months are indicated on the maps. During these months, several species of shorebirds utilize the Columbia River as a stopover in their migratory route including dunlin, sanderlings, sandpipers, and others. Substantial numbers of shorebirds may also overwinter in the estuary. Information on the locations of shorebird concentration areas was based on USFWS maps and expert information received from NOAA and USFWS staff.

Expert contacts for birds are Frank Issacs (bald eagles, OSU, Philomath, OR) 541/929-7154; Herman Biederbeck (ODFW, Tillamook, OR) 503/842-2741; Keith Kohl (ODFW, The Dalles, OR) 541/296-4628; Dan Roby (seabirds, OSU) 541/737-1955; Alan Clark (USFWS, Julia Butler Hansen NWR, Cathlamet, WA) 360/795-3915; Eric Anderson (USFWS, Ridgefield NWR complex) 360/887-

3883; and Mark Nebeker (ODFW, Sauvie Island Wildlife Area) 503/621-3488 ext. 25.

Birds are shown on the maps as polygons with a green hatch pattern. Nesting colonies are shown as green points or polygons in cases where multiple nests may extend over a wider area. The points may not necessarily be in the exact location of the nesting colonies. In cases where multiple resource types occupy the same polygon (such as birds and marine mammals), a black hatch, multi-group pattern is used rather than a green hatch pattern. A green icon (or icons) with the appropriate subgroup silhouette(s) is used to indicated the presence of different bird types (waterfowl, shorebirds, etc.). The appropriate icons are associated with all polygons containing birds.

The RAR# under the icon (or icon group) on the maps references a table on the reverse side of the map. In this table the first column contains the species common name. The second column indicated whether the species is listed as a species of special concern (C), threatened (T), or endangered (E) on the federal (F) list. The next column provides an estimate of the concentration of the species at the site. Concentration is usually represented by number of birds, although the term "high" may be used when an exact number is not known. Concentration numbers, when reported, are represented as the annual peak number of individuals present at a specific location. In some cases, concentration values have not been used if information was not available. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column. The last three columns denote the migratory or nesting seasonality, if applicable, for each species.

REPTILES

Few reptiles of concern are found along the Columbia River. The common western painted turtle is present in many areas along the river. In addition, the western pond turtle (Washington state endangered) has been released into several areas in an attempt to augment declining populations in the area. Nesting and foraging areas for the western pond turtle were determined based on expert knowledge and information provided by local USFWS staff.

The expert contact for the western pond turtle is Eric Anderson (USFWS, Ridgefield, WA) 306/887-3883.

Reptiles are depicted as polygons with a red hatch pattern. In cases where multiple resources types occupy the same polygon, a black hatch, multi-group pattern is used rather than a red hatch polygon. A red icon with a turtle silhouette is used to indicate the presence of reptiles and is associated with all polygons containing these resources.

The RAR# under the icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as a species of special concern (C), threatened (T) or endangered (E) on the federal (F) and/or state (S) lists. The next column provides an estimate of the concentration of the species at the site. Concentration is listed as "high" for areas of known usage by the western pond turtle. In some cases, concentration values have not been used because information was not available. Note that concentration should not be interpreted as the "level of concern" of "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species or resource is present at a location in a particular month, an "X" is placed in the month column.

FISH

Fish species depicted for Columbia River include selected estuarine, anadromous, and freshwater species. Species of commercial, recreational, ecological, and/or conservation interest are emphasized. Fish are mapped as multi-species assemblages to the greatest extent possible. Regional fish distributions were depicted with the assistance of ODFW, WDFW, and NOAA fish biologists.

Anadromous fish

Wild and hatchery-raised stocks of anadromous fish are major components of the freshwater ecosystem of the Columbia River. Chinook, chum, Coho, and sockeye salmon, rainbow trout (steelhead), and others are present in the area and utilize tributary rivers and streams along the Columbia River, as well as some areas in the mainstem, as spawning grounds. When adult fish return to their natal streams, they tend to concentrate at stream mouths prior to moving upstream. Most spawning beds are well upstream in the tributaries and are beyond the limit of tidal excursions that could carry oils slicks inland. In contrast, juvenile salmon and other fish species may concentrate in shallow, near shore habitats in the mainstem river and are likely to be impacted during a spill.

Within the Columbia River, several of the anadromous fish species have federal or state listed runs (e.g., Snake River fall Chinook run). The specific runs and their associated state or federal listings are presented in Table 1. Anadromous stream location for each fish species was depicted on the maps from data compiled by NOAA from ODFW, WDFW, and Streamnet digital data. Other areas of high concentrations of juvenile and adults in the mainstem river were identified by ODFW, USFWS, and NOAA staff. A review of selected species utilizing the Columbia River is presented below. Note that life history and seasonal presence for the following species is generalized for the entire Columbia River and local biologists should be consulted for exact run timings.

Chinook salmon

Three runs of Chinook salmon (*Oncorhynchus tshawytscha*) return to the lower Columbia River including spring Chinook, "tule" fall Chinook, and "bright" fall Chinook. Spring Chinook generally return to freshwater in March and April and spawn in the late summer. Spring Chinook juveniles migrate to the ocean after rearing in the river for one year. The distinction between the fall runs of Chinook refers to the timing of spawning. Both types of fall Chinook return to the Columbia River from August to October/November. However, "tule" fall Chinook spawn almost immediately in large tributary mainstems, while the "brights" spawn from November to January farther upriver. Juveniles for both types of fall Chinook migrate downstream as sub-yearlings during their first spring and summer. For the purposes of simplification on these maps, the two fall runs are treated as one. Several of the Chinook salmon runs are federally or state listed, and a review of those species can be found in Table 1.

Rainbow trout (Steelhead)

Similar to the Chinook salmon, the rainbow trout (Steelhead) (*Oncorhynchus mykiss*) has both summer and winter runs. Summer Steelhead typically enter the Lower Columbia River between May and October and spawn between February and April. In contrast, winter run Steelhead return from the ocean between December and May and generally spawn in April and May. Juveniles of both runs may rear in freshwater from 1 to 4 years before returning to the ocean. Several of the Steelhead runs are federally or state listed, and a review of those species can be found in Table 1.

Chum Salmon

Chum salmon (*Oncorhynchus keta*) return to the Columbia River to spawn from September through November. Most spawning occurs in the lower portions of the Columbia River tributaries and in some portions of the mainstem river. Chum fry migrate downstream to the ocean immediately after emergence from spawning beds. Annual runs of Chum have declined dramatically and now average only 4,000 fish, about 3% of the historic run size. All populations of Chum were listed as threatened in 1999 (Table 1). Hardy, Hamilton, and Ives Island areas in the mainstem river near Pierce NWR retain some of the last remaining Chum spawning grounds in the lower Columbia River, thus care should be taken to protect these areas in the event of an oil spill.

Coho salmon

Coho salmon (*Oncorhynchus kisutch*) return to the Columbia River as three year olds during the fall with most spawning for this species occurring in September and October. Juvenile Coho will rear for one year in the river prior to migrating to the ocean. Coho salmon are currently a candidate species under review for listing under the Endangered Species Act (Table 1.). Most Coho salmon present in the Columbia River are hatchery raised and released fish. Wild populations are generally believed to have been extirpated or to consist of no more than a few hundred fish.

Sockeye salmon

Sockeye salmon (*Oncorhynchus nerka*) return to the Columbia River at 3-5 years of age in June and July. Peak spawning months for this species are September and October. Juvenile Sockeye generally rear for one full year in freshwater lakes before migrating to the ocean. Sockeye salmon have declined dramatically in recent years from historic levels, and a portion of the Sockeye run was listed as endangered in 1991 (Table 1).

Sturgeon

Two species of sturgeon occur in the Columbia River, white sturgeon (*Acipenser transmontanus*) and the green sturgeon (*A. medirostris*). Both species are considered to be facultatively anadromous with the ability to live in both fresh and saltwater, but with no requirement for marine residence in their life history. Green sturgeon generally do not range far upstream from the estuary, while the white sturgeon is distributed throughout the Columbia River from the mouth to the John Day dam. The lower Columbia River below Bonneville Dam exhibits the most highly productive populations of white sturgeon on the entire west coast.

Expert contacts for anadromous and warm water fish in the area include Steve Stone (NMFS, Portland, OR) 503/231-2317; Ben Meyer (NMFS, Portland, OR) 503/230-5425; Steve Pribyl (ODFW, The Dalles, OR) 503/296-4628; Thomas Stahl (ODFW, Willamette

River, OR) 503/657-2000 ext. 231; John North (ODFW, Clackamas, OR) 503/657-2000 ext.251; Tom Rien (ODFW, Clackamas, OR) 503/657-2000 ext. 404; Wayne van der Naald (ODFW, Clackamas, OR) 503/657-2000 ext. 237; and Dan Guy (NOAA, Lacey, WA) 360/534-9342.

Fish are generally shown on the maps as polygons with a blue hatch pattern. Anadromous streams were depicted as linear features using a bright blue color readily distinguishable from the light blue color and black outline used for general hydrographic features. In cases where multiple resource types occupy the same polygon (such as fish and waterfowl), a black hatch, multi-group pattern is used rather than a blue hatch pattern. A blue icon with a fish silhouette is used to indicate the presence of fish. This icon is associated with all polygons or arcs containing fish.

The RAR# under the icon or icon group references a table on the reverse side of the map. In this table, the first column gives the species name. The second column denotes whether the species has been designated a species of special concern (C), endangered (E), or threatened (T) on either the state (S) and/or federal (F) lists. For anadromous salmon species an asterisk (*) appears on the data table. For those species refer to Table 1 below for detailed status information. The next column provides an estimate of the concentration of the species at the site. Descriptive terms such as "high" were used in most cases based upon information provided by ODFW and USFWS staff and adapted from WDFW priority habitat data. Concentration values were not used when no information was available.

The seasonality for each species or resource is shown in the next twelve columns corresponding to the months of the year. If a species or resource is present at a location in a particular month an "X" is placed in the month column. The last column denotes different life-history stages or activities including spawning, eggs, larvae, juveniles, and adults.

TABLE 1. Anadromous fish present in the Columbia River and its tributaries. Specific runs are classified as threatened (T), endangered (E), or candidate (Cand.) on either the federal and/or state (Washington, WA; Oregon, OR) level where applicable. The date of listing through the Endangered Species Act (ESA) is also given. S-C=Sensitive-Critical, S-V=Sensitive-Vulnerable, NL=Not listed.

Anadromous Fish	OR	WA	Federal (ESA)	ESA Year Listed
Chinook Salmon (Fall and Spring)				
Lower Columbia R. ESU	S-C	Cand.	T	1999
Upper Willamette R. ESU spring run	T	NL	T	1999
Upper Columbia R. spring run ESU	NL	Cand.	E	1999
Snake R. fall run ESU	T	Cand.	T	1992
Snake R. spring/summer run ESU	T	Cand.	T	1992
Rainbow Trout (Steelhead) (Winter and Summer)				
Lower Columbia R. ESU	S-C	Cand.	T	1998
Middle Columbia R. ESU	S-C	Cand.	T	1999
Upper Columbia R. ESU		Cand.	E	1997
Upper Willamette R. ESU winter run	S-C	NL	T	1999
Snake R. basin ESU	S-C	Cand.	T	1999
Sockeye Salmon				
Snake River ESU	NL	Cand.	E	1991
Coho Salmon				
Lower Columbia R./SW Wash. ESU	E (OR)	NL	Cand.	1995
Chum Salmon				
Columbia River ESU	S-C	Cand.	T	1999
Bull Trout				
Bull Trout-Columbia River Basin	S-C	NL	T	1998
Smelt (Euchalon)	NL	Cand.	NL	
White Sturgeon	NL	NL	NL	
Green Sturgeon	NL	NL	NL	

INVERTEBRATES

Invertebrate species of commercial, subsistence, recreational, ecological, and/or conservation interest are emphasized in this atlas and include crabs, clams, and mussels. Invertebrate distributions are based on information supplied by ODFW staff and WDFW priority habitat data.

The expert contact for invertebrates/shellfish in the Columbia River estuary is Matthew Hunter (ODFW, Astoria, OR) 503/325-2462.

Invertebrates are shown on the maps as polygons with an orange hatch pattern. An orange icon with a crab or bivalve silhouette is used to indicate the presence of these species. The icons are associated with all polygons or point features containing invertebrates.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Descriptive terms such as "high" were used in most cases based upon information provided by ODFW staff and WDFW priority habitat data. Concentration values were not used when no information was available.

The seasonality for each species or resource is shown in the next twelve columns corresponding to the months of the year. If a species or resource is present at a location in a particular month an "X" is placed in the month column. The last column denotes different life-history stages for invertebrates including spawning, eggs, larvae, juveniles, and adults.

BENTHIC HABITATS/RARE PLANTS

Eelgrass beds were mapped in the Columbia River estuary using expert opinion of NOAA and ODFW staff in conjunction with USFWS maps. Areas of concern for eelgrass include Grays Bay, Youngs Bay, and Bakers Bay in the estuary. Additional eelgrass beds may be present in other areas within the estuary.

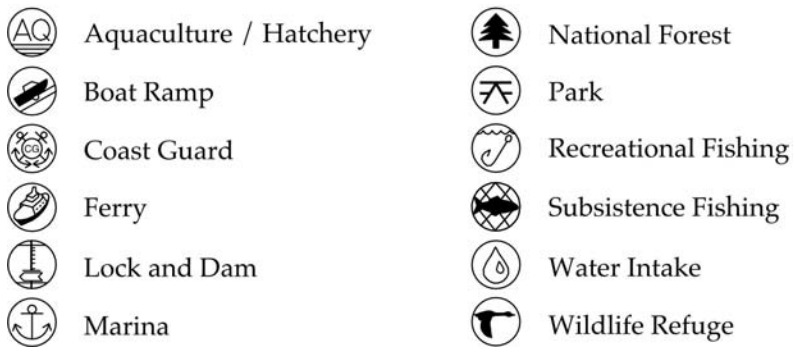
Individual plant species of particular concern depicted on the maps include the wetland species water howellia (*Howellia aquaticus*) (federal threatened) and Columbia yellow cress (*Rorippa columbiae*) (Washington State threatened). Water howellia occurs in the western wetland habitats of Ridgefield NWR while the Columbia yellow cress occurs in the seasonally inundated cobble habitats near Pierce NWR. Both species were mapped using maps provided by USFWS through the Ridgefield National Wildlife complex. Care should be taken in the event of a spill to prevent impacts to these species from oil as well as trampling during periods of annual growth.

The expert contact for water howellia and Columbia yellow cress is Eric Anderson (Ridgefield, WA) 360/887-3883.

Submersed habitats and rare plants are depicted as polygons shaded with a purple hatch pattern. In cases where multiple resource types occupy the same polygon (such as eelgrass and fish), a black hatch, multi-group pattern is used rather than a purple hatch polygon. A purple icon with the appropriate silhouette is used to indicate the presence of submersed habitats or plants and is associated with all polygons or point features containing these resources. The RAR# under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. Concentration is generally listed using a descriptive term, such as "high," "medium," or "low." Records for rare and endangered species may also contain "present" in the concentration field where more detailed concentration descriptions are not appropriate or not available. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. Submersed habitats and rare plants were mapped as being present year round.

HUMAN-USE FEATURES

The human use features depicted on the maps are those that could be impacted by an oil spill or could provide access for response operations. All the features are represented by icons indicating the type of human-use resource present. Many of the point features were mapped using digital data sources, expert information, published sources, and USGS topographical maps. Boat ramps and marina locations were supplemented by information gathered from the shoreline mapping overflights. Hardcopy maps were used to supplement or refine the digital management area data.



Aquaculture/Hatchery: Locations of aquaculture sites. When known, the site name, owner/manager, and contact information are provided on the data tables for each map. This information was provided by ODFW and WDFW staff.

Boat Ramp: Location of boat ramps. Boat ramp site names are provided on the data tables for each map, when available.

Coast Guard: Coast Guard station and marina.

Ferry: Sites where ferry landings are located.

Lock/Dam: Location of locks, dams, or similar structures.

Marina: Location of marinas. Marina names are provided on the data tables for each map, when available.

National Forest: Areas managed by USDA Forest Service.

Park: Areas managed by either Oregon State Parks or Washington State Parks for recreational and natural resource purposes. The property name, management agency, contact information, and telephone number are provided on the data table for each map.

Recreational Fishing: Location of recreational fishing sites. This information was provided by local experts.

Subsistence Fishing: Areas utilized by native Americans in Oregon and Washington for the collection of fish and shellfish.

Water Intake: Location of water intake. For most water intakes, the site name, owner/manager, contact person, and telephone number are provided on the data table for each map.

Wildlife Refuge/Management Areas: Areas managed by the USFWS as National Wildlife Refuges or by the State as Wildlife Management Areas. The property name, management agency, contact information, and telephone number are provided on the data table for each map.

GEOGRAPHIC INFORMATION SYSTEM

The entire atlas product is stored in digital form in a Geographic Information System (GIS) as spatial data layers and associated databases. The format for the data varies depending on the type of information or features for which the data are being stored.

Under separate cover is a metadata document that details the data dictionary, processing techniques, data lineage, and other descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Refer to the metadata file for a full explanation of the data and its structure.

SHORELINE CLASSIFICATIONS

The ESI shoreline habitat classification is stored as lines and polygons with associated attributes. In many cases, a shoreline may have two or three different classifications or colored lines on the shoreline. These multiple classifications are represented on the maps by double and triple line patterns and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. In addition to the line features, exposed wave-cut platforms (ESI = 2A), tidal flats (ESI = 7, ESI = 9A), marshes (ESI=10A, ESI=10B), swamps (ESI=10C), and Scrub-Shrub Wetlands (ESI = 10D) are also stored as polygons. Therefore, the legend on each map may contain two patterns depicted on a map: a linear feature as well as a polygonal feature.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as polygons or points. Associated with each feature is a unique identification number that is linked to a series of data tables that further identify the resources. The main biological resource table consists of a list of species identification numbers for each site, the concentration of each species at each site, and identification codes for seasonality and source information. This data table is linked to other tables that describe the seasonality and life-history time-periods for each species (at month resolution) for the specified map feature. Other data tables linked to the first table include: the species identification table, which includes common and scientific names; the species status table, which gives information for state and/or federal threatened or endangered listings; and the source database, which provides source metadata at the feature-species level (specific sources are listed for each species occurring at each mapped feature in the biology coverages).

HUMAN-USE FEATURES

Human-use features are represented as lines, points, or polygons. The resource name, the owner/manager, a contact person, and phone number are included in the database for management areas, water intakes, marinas, and aquaculture sites when available. All metadata sources are documented at the feature level.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication concerning resources depicted in the atlas.

Collis, K., D.D. Roby, D.E. Lyons, R.M. Suryan, M. Antolos, S.K. Anderson, A.M. Myers, D.P. Craig, and M. Hawbecker. 2002. Caspian Tern research on the Lower Columbia River: Final 2002 Season Summary. A report submitted to the Bonneville Power Administration and the Interagency Caspian tern working group. 31 pp.

Columbia River Estuary Data Development Program, 1984. The Columbia River Estuary Atlas of Physical and Biological Characteristics. Northwest Cartography, Inc. Seattle, Wash., 49 pp.

Engler, J., D. Friesz, E. Anderson, and D. Anderson. 2004. Final Status Report on the 2003 Greater Sandhill Crane Nesting Season at Conby Lake National Wildlife Refuge, Klickatat County, Washington. U.S. Fish and Wildlife Service Report. 7 pp.

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Lower Columbia Fish Recovery Board. 2003. Draft Lower Columbia River Recovery/Subbasin Technical Foundation. Volumes 1-3. Unpub. Report. Submitted to NOAA Fisheries, USFWS, Wash. State, and NPCC.

Monaco, M., D. Nelson, R. Emmett and S. Hinton. 1990. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume 1: Data Summaries. ELMR Rep. No. 4. NOAA/NOS Strategic Environmental Assessments Division, Silver Springs, Md., 232 pp.

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ACKNOWLEDGEMENTS

This project was supported by the NOAA Office of Response and Restoration, Hazardous Materials Response Division. Access to aerial photography was provided by NOAA.

The biological and human-use data included on the maps were provided by numerous individuals, agencies, and organizations.

Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), the National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), Oregon State University (OSU), Washington State Parks (WSP), Oregon State Parks (OSP), Washington Department of Ecology (WADOE), Department of the Interior (DOI), the Bureau of Land Management (BLM), and the Lower Columbia River Estuary Program (LCREP) staff from several divisions and programs contributed a vast amount of information to this effort, including first-hand expertise, publications, reports, maps, and digital data. Specific individuals and references used directly as source material are detailed in the metadata report that accompanies the digital data set. At Research Planning, Inc. (RPI) of South Carolina, numerous scientific, GIS, and graphics personnel were involved with different phases of the project. Shoreline habitat mapping was conducted by Colin Plank. The biological and human-use data were collected, compiled, and edited by Amy Gras-Mead and Christine Lord. Jon Whitlock, Lee Diveley, and Chris Locke entered, processed, and produced the GIS data under the supervision of Mark White, GIS director. Cartographic design and graphic art production was provided by Joe Holmes. Vermell Simon and Wendy Early prepared the final text documents and metadata.

APPROPRIATE USE OF ATLAS AND DATA

This atlas and the associated database were developed to provide summary information on sensitive natural and human-use resources for the purposes of oil and hazardous materials spill planning and response. Although the atlas and database should be very useful for other environmental and natural resource planning purposes, it should not be used in place of data held by WDFW, ODFW, USFWS, NOS, NMFS, BLM, or other agencies. Likewise, information contained in the atlas and database cannot be used in place of consultations with natural and cultural resource agencies, or in place of field surveys. This atlas should not be used for navigation.

SPECIES LIST

*Common Name	*Species Name

MARINE MAMMALS

PINNIPED

Steller sea lion	*Eumetopias jubatus*
Harbor seal	*Phoca vitulina*
California sea lion	*Zalophus californianus*

TERRESTRIAL MAMMALS

SMALL MAMMAL

Northern river otter	*Lutra canadensis*
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethicus*
Mink	*Mustela vison*
Nutria	*Myocastor coypus*

UNGULATE

Columbian white-tailed deer	*Odocoileus virginianus leucurus*

BIRDS

DIVING BIRDS

Western grebe	*Aechmophorus occidentalis*
Double-crested cormorant	*Phalacrocorax auritus*
Brandt's cormorant	*Phalacrocorax penicillatus*
Pelagic cormorant	*Phalacrocorax pelagicus*
Brown pelican	*Pelecanus occidentalis*
Loons	*Gavia spp.*
Grebes	

GULLS AND TERNS

Glaucous-winged gull	*Larus glaucescens*
Western gull	*Larus occidentalis*
Ring-billed gull	*Larus delawarensis*
Caspian tern	*Sterna caspia*
Gulls	

PASSERINES

Purple martin	*Progne subis*

RAPTORS

Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Peregrine falcon	*Falco peregrinus*
Goshawk	*Accipiter gentilis*
Turkey vulture	*Cathartes aura*

SHOREBIRDS

Spotted sandpiper	*Actitis macularia*
Dunlin	*Calidris alpina*
Western sandpiper	*Calidris mauri*
Sanderling	*Calidris alba*
Killdeer	*Charadrius vociferus*
Shorebirds	

WADING BIRDS

Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Green heron	*Butorides virescens*
Sandhill crane	*Grus canadensis*
Wading birds	

WATERFOWL

Tundra swan	*Cygnus columbianus*
Canada goose	*Branta canadensis*
Greater white-fronted goose	*Anser albifrons*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Canvasback	*Aythya valisineria*
Common goldeneye	*Bucephala clangula*
Harlequin duck	*Histrionicus histrionicus*
White-winged scoter	*Melanitta fusca*
Surf scoter	*Melanitta perspicillata*
Common merganser	*Mergus merganser*
American coot	*Fulica americana*
American wigeon	*Anas americana*
Trumpeter swan	*Cygnus buccinator*
Dusky Canada goose	*Branta canadensis occidentalis*
Wood duck	*Aix sponsa*
Aleutian Canada goose	*Branta canadensis leucopareia*
Geese	
Scaup	*Aythya spp.*
Waterfowl	
Dabbling ducks	
Diving ducks	
Ducks	
Swans	*Cygnus spp.*

*Common Name	*Species Name

REPTILE

TURTLE

Western pond turtle	*Clemmys marmorata*
Western painted turtle	*Chrysemys picta bellii*

FISH

FISH

White sturgeon	*Acipenser transmontanus*
Green sturgeon	*Acipenser medirostris*
Coastal Cutthroat trout	*Oncorhynchus clarkii clarkii*
Coho salmon	*Oncorhynchus kisutch*
Sockeye salmon	*Oncorhynchus nerka*
Chum salmon	*Oncorhynchus keta*
Eulachon	*Thaleichthys pacificus*
Salmon	
American shad	*Alosa sapidissima*
Pacific lamprey	*Lampetra tridentata*
Chinook salmon (fall)	*Oncorhynchus tshawytscha (fall)*
Chinook salmon (winter)	*Oncorhynchus tshawytscha (winter)*
Chinook salmon (spring)	*Oncorhynchus tshawytscha (spring)*
Rainbow trout (summer)	*Oncorhynchus mykiss (summer)*
Rainbow trout (winter)	*Oncorhynchus mykiss (winter)*
Bull trout	*Salvelinus confluentus*
Chinook salmon (summer)	*Oncorhynchus tshawytscha*
Starry flounder	*Platichthys stellatus*
Common carp	*Cyprinus carpio*
Smallmouth bass	*Micropterus dolomieu*
Walleye	*Stizostedion vitreum vitreum*
White crappie	*Pomoxis annularis*

INVERTEBRATES

BIVALVES

Softshell clam	*Mya arenaria*
Pacific razor clam	*Siliqua patula*
Pacific littleneck	*Protothaca staminea*
Nuttall cockle	*Clinocardium nuttallii*
Freshwater mussel	*Anodonta spp.*

CRABS

Dungeness crab	*Cancer magister*

HABITATS

FLOATING AQUATIC VEGETATION (FAV)

Water howellia	*Howellia aquatilis*

SUBMERSED AQUATIC VEGETATION (SAV)

Eelgrass	*Zostera marina*
Columbian yellowcress	*Rorippa columbiae*

* Threatened and endangered species and species of special concern are designated by underlining

SHORELINE DESCRIPTIONS

EXPOSED ROCKY SHORES **ESI = 1A**

DESCRIPTION

- The intertidal zone is steep (greater than 30° slope), with very little width; solid and composed of bedrock
- Sediment accumulations are uncommon because waves and currents remove debris slumped from the eroding cliffs
- There is strong vertical zonation of intertidal biological communities in the estuarine parts of the river
- This shoreline type is regularly exposed to wave action and strong currents
- Wave reflection is a common phenomena along the outer coast
- Species density and diversity vary greatly depending on exposure and salinity, but barnacles, snails, mussels, amphipods, and macroalgae can be abundant
- Present sparsely throughout the estuary, the most spectacular example is Cape Disappointment at the mouth; common along the river mainstem

PREDICTED OIL BEHAVIOR

- In the lower estuary and outer coast, oil is held offshore by waves reflecting off the steep, hard surfaces; Any oil that is deposited is rapidly removed from exposed faces
- Along the river, oil can form a band at the high water line
- The most resistant oil would remain as a patchy band at or above the high-water line

- Impacts to intertidal communities are expected to be short-term in duration. An exception would be where heavy concentrations of a light refined product comes ashore very quickly

RESPONSE CONSIDERATIONS

- Cleanup is usually not required
- Access can be difficult and dangerous

EXPOSED, SOLID MAN-MADE STRUCTURES **ESI = 1B**

DESCRIPTION

- These structures are solid, man-made structures such as seawalls, groins, revetments, piers, and port facilities
- Many structures are constructed of concrete, wood, or metal
- Often there is no exposed substrate at low tide, but multiple habitats are indicated if present
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes
- Attached animals and plants are sparse to moderate
- They are common along commercial zones and waterways

PREDICTED OIL BEHAVIOR

- Oil can be held offshore by waves reflecting off the vertical, hard surface in exposed settings
- Oil readily adheres to the dry, rough surfaces at the high-tide line, but it does not adhere to wet substrates
- The most resistant oil would remain as a patchy band at or above the high-tide line

- High-pressure water spraying may be conducted to remove persistent oil in crevices, improve aesthetics, and prevent direct contact with oiled surfaces

RESPONSE CONSIDERATIONS

- Cleanup is usually not required

EXPOSED WAVE-CUT PLATFORMS IN BEDROCK **ESI = 2A**

DESCRIPTION

- They are characterized by a flat or gently sloping shelf or platform that is exposed to regular waves or currents
- Although the platform is composed of bedrock, portions of the platform may be covered by a thin patches of sediments
- The surface of the platform is irregular with numerous crevices; tidal pools are common
- Species density and diversity varies greatly along the salinity gradients
- Present throughout the river, with the largest areas near the John Day dam

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet rock surface, but could penetrate crevices or patches of sediments
- Persistence of oil is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity

RESPONSE CONSIDERATIONS

- Cleanup is usually not required except for areas of high recreational use

- Where the shoreline is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris

FINE- TO MEDIUM-GRAINED SAND BEACHES ESI = 3A

DESCRIPTION

- These beaches are flat to moderately sloping and relatively hard packed
- There can be heavy accumulations of wrack present
- They are important habitats for migratory and summer nesting birds
- Common within the estuary, best examples are on Sand Island

PREDICTED OIL BEHAVIOR

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide
- Maximum penetration of oil into fine- to medium-grained sand is about 10-15 cm
- Burial of oiled layers by clean sand within the first week after a spill typically will be less than 30 cm along the upper beach face
- Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water
- Biological impacts include temporary declines in infauna, which can affect important shorebird foraging areas

RESPONSE CONSIDERATIONS

- These beaches are among the easiest shoreline types to clean
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore

- Traffic through both oiled and dune/riparian areas should be severely limited, to prevent contamination of clean areas
- Manual cleanup is advised to minimize the volume of sand removed from the shore and requiring disposal
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic
- Mechanical reworking of lightly oiled sediments from the high-tide line to the middle intertidal zone may be effective along outer beaches

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SCARPS AND STEEP SLOPES IN SAND ESI = 3B

DESCRIPTION

- These scarps are composed of relatively soft, unconsolidated sediments
- The scarps show evidence of active erosion, and beaches in front of the scarps are narrow or absent
- They are common generally at cut-banks of smaller tributaries

PREDICTED OIL BEHAVIOR

- Any stranded oil will form a band along the high-water line.
- There is some potential for oil penetration into any sediment accumulations at the base of the scarp, but active erosion of the scarp will also erode the oil

RESPONSE CONSIDERATIONS

- In some cases, cleanup is not necessary because of the short residence time of the oil
- The need for removal of oiled sediments should be carefully evaluated because of the potential for increased erosion
- Manual labor and close supervision should be used so that the minimal amount of sediment is removed during cleanup

COARSE-GRAINED SAND BEACHES ESI = 4

DESCRIPTION

- Highly variable beachface slopes; sediments are soft and permeable with low trafficability
- The rate of sediment mobility is relatively high, as the beachface is reworked by boat wakes
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Very common over entire length of river

PREDICTED OIL BEHAVIOR

- During small spills oil is deposited primarily as a band along the high-water line
- Under heavy accumulations oil may spread across the entire intertidal zone, though it will be lifted off the lower part of the beach during rising tides or water levels in the river
- Penetration up to 25 cm is possible
- Burial of oiled layers by clean sand can be rapid
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Cleanup more difficult than for finer-grained beaches, because equipment tends to grind oil into the substrate due to the loosely packed and permeable nature of these coarser-grained sediments; therefore, special care must be exercised while using heavy equipment to prevent mixing oil deeper into the beach sediment

- Use of heavy equipment for oil/sand removal may also result in the export of excessive amounts of sand; therefore, where feasible and for smaller amounts of oil, manual cleanup may be desirable
- Vehicular and foot traffic through oiled areas and riparian habitat should be limited to prevent contamination of clean areas and disturbance of riparian vegetation
- Removal of sediment should be limited as much as possible to avoid erosion problems on the beach in the future; however, the common occurrence of multiple buried oil layers in these types of beaches increases the amount of sediment to be handled and disposed of

MIXED SAND AND GRAVEL BEACHES ESI = 5

DESCRIPTION

- Moderately sloping beach composed of a mixture of sand and gravel (gravel component should comprise between 20 to 80 percent of total sediments)
- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms
- Because of sediment desiccation and mobility on exposed beaches, there are low densities of attached animals and plants
- Uncommon in the lower estuary, occurring as small pocket beaches within the estuary and near Cape Disappointment
- Common along the river, generally found at the mouths of smaller tributaries such as the Sandy River in Troutdale

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along and above the high-tide swash
- Large spills will spread across the entire intertidal area
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent
- Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to reworking by waves
- In sheltered pockets on the beach, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations
- Once formed, asphalt pavements can persist for many years

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed quickly from the upper beachface
- All oiled debris should be removed
- Sediment removal should be limited as much as possible
- Low-pressure flushing may be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of the potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone may be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone
- In-place tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches

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GRAVEL BEACHES ESI = 6A

DESCRIPTION

- Gravel beaches can be steep, with multiple wave-built berms forming the upper beach. Gravel beaches have the lowest trafficability of all beach types and may contain shell and woody debris
- Because of the high mobility of sediments on exposed gravel beaches, there are low densities of animals and plants
- Common, especially on the north side of estuary and very common along the river mainstem

PREDICTED OIL BEHAVIOR

- Deep penetration of stranded oil is likely on gravel beaches because of their high permeability
- Long-term persistence will be controlled by the depth of routine reworking by waves and boat wakes
- Along sheltered portions of the shorelines, chronic sheening and the formation of asphalt pavements is likely where accumulations are heavy

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed quickly from the upper beachface
- All oiled debris should be removed
- Sediment removal should be limited as much as possible
- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents

- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone may be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone
- In-place tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches

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RIPRAP ESI = 6B

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of rock
- Riprap structures are used for shoreline protection and as jetties in harbors
- Attached biota are sparse on exposed riprap
- They are common in Astoria and over the entire length of river, associated with boat ramps, dams, and railroads

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the blocks is likely
- Oil adheres readily to the rough surfaces of the blocks
- Uncleaned oil can cause chronic leaching until the oil hardens

RESPONSE CONSIDERATIONS

- When the oil is fresh and liquid, high pressure spraying and/or water flooding may be effective, making sure to recover all liberated oil

- Heavy and weathered oils are more difficult to remove, requiring scraping and/or hot-water spraying

EXPOSED TIDAL FLATS — ESI = 7

DESCRIPTION

- Exposed tidal flats are broad, flat intertidal areas composed primarily of sand and minor amounts of gravel (in a few areas)
- The presence of sand and gravel indicates that tidal currents and waves are strong enough to mobilize the sediments
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish
- They are very common in the lower estuary and sometimes occur on the seaward, more exposed edge of a larger mudflat

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil does not penetrate water-saturated sediments
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators

RESPONSE CONSIDERATIONS

- Currents and waves can be very effective in natural removal of the oil
- Cleanup is very difficult (and possible only during low tides)
- The use of heavy machinery should be restricted to prevent mixing of oil into the sediments

SHELTERED ROCKY SHORES — ESI = 8A

DESCRIPTION

- The substrate is solid and composed of bedrock
- This shoreline type is sheltered from large waves and strong currents
- Sediments may accumulate at the base of this shoreline type
- The slope of the intertidal zone is generally moderate to steep (greater than 15°) with little width
- Sheltered rocky shores are moderately common in the lower estuary; Not common along the river mainstem, mostly occurred along the banks of the Willamette River

PREDICTED OIL BEHAVIOR

- Heavy oils tend to coat the dry, irregular surface
- Stranded oil will persist because of low energy setting

RESPONSE CONSIDERATIONS

- Low-pressure flushing at ambient temperatures is most effective when the oil is fresh and still liquid
- Care must be taken during flushing operations to prevent oily effluents from affecting biologically rich, lower intertidal levels
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris

SHELTERED, SOLID MAN-MADE STRUCTURES — ESI = 8B

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities
- Structures are constructed of concrete, wood, or metal
- Often there is no exposed beach at low water, but multiple habitats are indicated if present
- Attached animal and plant life is highly variable
- They are common in developed commercial waterfront areas such as around Astoria and Portland, also common along the Willamette River and in association with dams

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to rough surfaces, particularly along the high-tide line, forming a distinct oil band
- The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface

RESPONSE CONSIDERATIONS

- Cleanup of seawalls is usually conducted for aesthetic reasons or to prevent leaching of oil
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh

SHELTERED RIPRAP **ESI = 8C**

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of rock
- These structures are found inside harbors and bays in highly developed areas, sheltered from direct exposure to waves
- Attached animal and plant life can be present
- Sheltered riprap is very uncommon in the mapped area

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely
- Oil adheres readily to the rough surfaces
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required to remove oil for aesthetic reasons and to prevent leaching of oil from the structure

- Cleanup crews should make sure to recover all released oil

SHELTERED TIDAL FLATS **ESI = 9A**

DESCRIPTION

- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell
- They are present in calm-water habitats, sheltered from major wave activity, and frequently backed by marshes
- The sediments are very soft and cannot support even light foot traffic in many areas
- They can have heavy wrack deposits along the upper fringe
- Large concentrations of shellfish, worms, and snails can be found on and in the sediments
- They are heavily utilized by birds for feeding
- Large sheltered muddy flats are very common throughout the lower estuary, generally associated with islands of saltmarsh such as Russian Island

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and desiccation cracks or other crevices in muddy sediments
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the flats

- Biological damage may be severe

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; deflection or sorbent booms and open water skimmers should be used
- Cleanup of the flat surface is very difficult because of the soft substrate; many methods may be restricted
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful

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SHELTERED, VEGETATED LOW BANKS **ESI = 9B**

DESCRIPTION

- These habitats are composed of low banks with grasses or shrubs along smaller tributaries
- They can be flooded occasionally by high water
- These habitats can be important for fish, shellfish, birds, and terrestrial mammals
- They are occur in the riverine sections, along the smaller tributaries, with minimal tidal water level changes

PREDICTED OIL BEHAVIOR

- During low water, it is unlikely that oil in the main river would affect these areas; however, during high river levels, oil could flow into them
- Oil will coat any vegetation at the water line
- Oil can contaminate and become trapped in debris

RESPONSE CONSIDERATIONS

- Low-pressure flushing may be effective in small waterbodies, to flush oil trapped along the banks and in debris to collection sites
- Care should be taken to prevent mixing of oil into sediments during response activities
- Deployment of sorbents may be necessary to recover sheens after gross oil removal

SALT- AND BRACKISH-WATER MARSHES **ESI = 10A**

DESCRIPTION

- Intertidal wetlands containing emergent, herbaceous vegetation
- Width of the marsh can vary widely, from a narrow fringe to extensive areas
- Marsh soils can range from sand to high-organic peats
- Exposed areas are located along bays with wide fetches and along heavily trafficked waterways
- Sheltered areas are not exposed to significant wave or boat wake activity
- Resident flora and fauna are abundant with numerous species with high utilization by birds, fish, and shellfish
- They are very common in the lower estuary, particularly in the Lewis and Clark National Wildlife Refuge

PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands
- Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of tidal influence
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter)

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery; natural removal processes and rates should be evaluated prior to conducting cleanup
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Cleanup activities should be carefully supervised to avoid vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place

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FRESHWATER MARSHES **ESI = 10B**

DESCRIPTION

- These are grassy wetlands composed of emergent herbaceous vegetation in tidal freshwater settings
- Marsh soils can vary widely from sand and gravel to peat
- Resident flora and fauna are abundant
- Common throughout riverine areas as both extensive islands and narrow fringing marsh

PREDICTED OIL BEHAVIOR

- Oil adheres readily to the vegetation
- The band of coating will vary widely, depending upon the water level changes at the time oil slicks are in the vegetation. There may be multiple bands
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery; natural removal processes and rates should be evaluated prior to conducting cleanup
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Cleanup activities should be carefully supervised to avoid vegetation damage

- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place

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SWAMPS **ESI = 10C**

DESCRIPTION

- Swamps consist of shrubs and hardwood forested wetlands. Vegetation is taller, on average, than 6 meters
- Sediments are silty clay with large amounts of organic debris
- They are seasonally flooded, though there are areas that are permanently flooded, mostly along the floodplains of tributaries or man-made impoundments
- Flora and fauna are abundant with numerous species
- They occur in inland areas, often along stream floodplains and as isolated wetlands

PREDICTED OIL BEHAVIOR

- They are risk of oiling from river spills during high-water events and spills from land
- Oil can penetrate into loose organic-rich soils and root cavities where there is no standing water
- Woody vegetation is less sensitive than grasses to oil

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. Cleanup is usually difficult and intrusive

- Oily debris can be removed where there is access
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Woody vegetation should not be cut

SCRUB-SHRUB WETLANDS **ESI = 10D**

DESCRIPTION

- Scrub-shrub wetlands consist of woody vegetation less than 6 meters tall including true shrubs, small trees, and trees and shrubs that are stunted due to environmental conditions
- The sediments are silty clay mixed with organic debris
- They grow above normal spring high tides, thus they are seldom inundated by salt water
- Resident flora and fauna are abundant
- They are usually found in association with artificial ponds created by railroad tracks

PREDICTED OIL BEHAVIOR

- They are generally not a risk of oiling from marine spills because of their position above normal high tides
- They could become oiled during very high water levels, from land-based spills, or during cleanup of adjacent areas
- Woody vegetation is less sensitive than grasses to oil

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is natural recovery
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing
- Oily debris can be removed where there is access
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized
- Woody vegetation should not be cut